

# REL Appalachia Ask A REL Response

Math, Online Courses  
June 2020

## Question:

What are evidence-based digital math games that elementary and middle school students can play at home during the summer?

## Response:

Thank you for your request to our REL Reference Desk regarding evidence-based information about digital math games that can be played at home. Ask A REL is a collaborative reference desk service provided by the 10 Regional Educational Laboratories (RELs) that, by design, functions much in the same way as a technical reference library. Ask A REL provides references, referrals, and brief responses in the form of citations in response to questions about available education research.

Following an established REL Appalachia research protocol, we searched for peer-reviewed articles and other research reports on digital math games that elementary and middle school students can play at home during the summer months. The sources included ERIC and other federally funded databases and organizations, research institutions, academic research databases, and general Internet search engines. For more details, please see the methods section at the end of this document.

The research team did not evaluate the quality of the resources provided in this response; we offer them only for your reference. Also, the search included the most commonly used research databases and search engines to produce the references presented here, but the references are not necessarily comprehensive, and other relevant references and resources may exist. References are listed in alphabetical order, not necessarily in order of relevance.

## References

Berkowitz, T., Schaeffer, M. W., Maloney, E. A., Peterson, L., Gregor, C., Levine, S. C., & Beilock, S. L. (2015). Math at home adds up to achievement in school. *Science*, *350*(6257), 196–198.  
[https://pdfs.semanticscholar.org/1ee0/fd92b83e4032bae05006b695a83be9485c2f.pdf?\\_ga=2.39767331.1662650261.1591102853-1153490901.1586191215](https://pdfs.semanticscholar.org/1ee0/fd92b83e4032bae05006b695a83be9485c2f.pdf?_ga=2.39767331.1662650261.1591102853-1153490901.1586191215)

*From the abstract:* “With a randomized field experiment of 587 first-graders, we tested an educational intervention designed to promote interactions between children and parents relating to math. We predicted that increasing math activities at home would increase

children's math achievement at school. We tested this prediction by having children engage in math story time with their parents. The intervention, short numerical story problems delivered through an iPad app, significantly increased children's math achievement across the school year compared to a reading (control) group, especially for children whose parents are habitually anxious about math. Brief, high-quality parent-child interactions about math at home help break the intergenerational cycle of low math achievement."

Fisch, S.M., Lesh, R., & Motoki, E. (2009). Exploring children's mathematical reasoning when playing online mathematical games. In S. L. Swars, D. W. Stinson, & S. Lemons-Smith (Eds.), *Proceedings of the 31st Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, (pp. 1489–1496). [https://www.researchgate.net/publication/265037361\\_EXPLORING\\_CHILDREN%27S\\_MATHEMATICAL\\_REASONING\\_WHEN\\_PLAYING\\_ONLINE\\_MATHEMATICS\\_GAMES](https://www.researchgate.net/publication/265037361_EXPLORING_CHILDREN%27S_MATHEMATICAL_REASONING_WHEN_PLAYING_ONLINE_MATHEMATICS_GAMES)

*From the abstract:* "Students have many opportunities for learning mathematics content outside of school. These informal interactions can be rich resources for students and teachers as they weave connections between the mathematics they study in school and the mathematics they experience outside of school. In this study we explored possible connections between formal and informal mathematics by investigating the mathematical reasoning used by students as they played online games. We report on students' interactions with the embedded mathematical content of the online games used in this study. Noting, in particular, the ways in which students engaged in increasingly more sophisticated mathematical reasoning as they progressed through the various levels in the games. These shifts in gameplay were detectable, not only through in-person observations, but also via data mining of online tracking data. Implications for the use and study of children's use of educational games as contexts for informal and formal learning of mathematics are discussed."

Hieftje, K., Pendergrass, T., Kyriakides, T. C., Gilliam, W., & Fiellin, L. (2017). An evaluation of an educational video game on mathematics achievement in first grade students. *Technologies*, 5(2), 30. <https://www.mdpi.com/2227-7080/5/2/30/htm>

*From the abstract:* "Development of early math skills is linked to future success in mathematics and other academics. Educational video games have been shown to promote academic achievement; however, few rigorous studies have evaluated the use of educational video games in supporting math development, especially in early primary education. In the current study, an open-label randomized controlled trial was conducted involving 134 first grade students to determine, using standardized assessments, the impact of the educational mathematics tablet-based video game, Knowledge Battle, on math scores and self-competency. Overall, Knowledge Battle did improve math skills in participants who played the game. Among those with lower pre-game math skills, the Knowledge Battle group's mean math score increased more than the control group's mean math score (9.7 vs. 6.0;  $p = 0.02$ ). There was no association between perceived sense of self-competency and total math score ( $p = 0.8141$ ). However, players who had a higher sense of self-competency were more likely to enjoy playing the game. In conclusion, our findings suggest that Knowledge Battle was an acceptable and enjoyable educational mathematical video game for first grade students, and may be most impactful for those with low math skills."

Lomas, D., Ching, D., Stampfer, E., Sandoval, M., & Koedinger, K. (2011). "Battleship Numberline:" A digital game for improving estimation accuracy on fraction number lines. Society for Research on Educational Effectiveness. <https://eric.ed.gov/?id=ED528880>

*From the abstract:* "Given the strong relationship between number line estimation accuracy and math achievement, might a computer-based number line game help improve math achievement? In one study by Rittle-Johnson, Siegler, and Alibali (2001), a simple digital game called 'Catch the Monster' provided practice in estimating the location of decimals on a number line. The authors found that improving number line estimation accuracy transferred to other conceptual skills, such as the ability to compare the magnitudes of different decimal values. To our knowledge, however, no research has yet demonstrated any benefits from improving number line estimation accuracy in the domain of fractions. As the first step in an ongoing research study to investigate the benefits of improving number line estimation skills with fractions, this paper presents preliminary findings gathered by a novel digital game, 'Battleship Numberline.' This study advances the area of number line research by demonstrating that students can make significant gains in estimation accuracy with just 20 minutes of game play."

McLaren, B. M., Adams, D. M., Mayer, R. E., & Forlizzi, J. (2017). A computer-based game that promotes mathematics learning more than a conventional approach. *International Journal of Game-Based Learning (IJGBL)*, 7(1), 36–56. Abstract retrieved from <https://eric.ed.gov/?id=EJ1119846>; full text available at <http://www.cs.cmu.edu/~bmclaren/pubs/McLarenEtAl-ComputerBasedGameThatPromotesMathLearningMoreThanAConventionalApproach-IJGBL2017.pdf>.

*From the abstract:* "Excitement about learning from computer-based games has been palpable in recent years and has led to the development of many educational games. However, there are relatively few sound empirical studies in the scientific literature that have shown the benefits of learning mathematics from games as opposed to more traditional approaches. The empirical study reported in this paper provides evidence that a mathematics educational game can provide superior learning opportunities, as well as be more engaging. In a study involving 153 students from two middle schools, 70 students learned about decimals from playing an educational game—Decimal Point—whereas 83 students learned the same content by a more conventional, computer-based approach. The game led to significantly better gain scores in solving decimal problems, on both an immediate ( $d = .43$ ) and delayed ( $d = .37$ ) posttest and was rated as significantly more enjoyable ( $d = .95$ ). Low prior knowledge students especially benefitted from the game. This paper also summarizes the game's design characteristics."

Pope, H., & Mangram, C. (2015). Wuzzit Trouble: The influence of a digital math game on student number sense. *International Journal of Serious Games*, 2(4). [https://www.researchgate.net/publication/287126963\\_Wuzzit\\_Trouble\\_The\\_Influence\\_of\\_a\\_Digital\\_Math\\_Game\\_on\\_Student\\_Number\\_Sense](https://www.researchgate.net/publication/287126963_Wuzzit_Trouble_The_Influence_of_a_Digital_Math_Game_on_Student_Number_Sense)

*From the abstract:* “This study sought to determine if playing a digital math game could increase student number sense (mathematical proficiency in numeracy). We used a pre- and post-assessment to measure the number sense of two groups of third grade students with the same mathematics teacher. One group played the game Wuzzit Trouble and the other did not. Overall, the group who played Wuzzit Trouble showed a significant increase in number sense between the pre- and post-assessment, compared to the other group who did not. A qualitative analysis of a novel problem revealed differences between the treatment and comparison groups from pre- to post-. A discussion of these findings and features of the game are addressed. Namely, two features inherent in Wuzzit Trouble are associated with the learners’ increased number sense. First, Wuzzit Trouble promoted mathematical proficiency by requiring learners to attend to several mathematical constraints at once. Second, the game engaged learners in an iterative process of decision-making by calling for students to try, check, and revise their strategy as they played.”

Riconscente, M. M. (2013). Results from a controlled study of the iPad fractions game motion math. *Games and Culture*, 8(4), 186–214.

[https://pdfs.semanticscholar.org/ab3e/a7f892852606f1a99fdb0f504d5f0383ba75.pdf?\\_ga=2.261565381.93820833.1592869016-280468865.1588628408](https://pdfs.semanticscholar.org/ab3e/a7f892852606f1a99fdb0f504d5f0383ba75.pdf?_ga=2.261565381.93820833.1592869016-280468865.1588628408)

*From the abstract:* “Although fractions knowledge is essential for future success in mathematics, data show that most U.S. students fail to become proficient in fractions. With the advent of mobile technologies such as iPad tablets, new kinds of interactions with subject matter have become possible that have potential for improving learning. The present study used an experimental repeated measures crossover design to investigate whether the iPad fractions game Motion Math would improve fourth graders’ fractions knowledge and attitudes. In results from 122 participants, students’ fractions test scores improved an average of over 15% after playing Motion Math for 20 min daily over a 5-day period, representing a significant increase compared to a control group. In addition, children’s self-efficacy for fractions, as well as their liking of fractions, each improved an average of 10%, representing a statistically significant increase compared to a control group. Implications for the design and study of interactive games are discussed.”

### *Additional Organizations to Consult*

PBS KIDS: <https://pbskids.org/>

*From the website:* “PBS KIDS is committed to making a positive impact on the lives of children through curriculum-based entertainment. With a 360-degree approach towards learning and reaching children, PBS KIDS leverages the full spectrum of media and technology to build knowledge, critical thinking, imagination and curiosity. By involving parents, teachers, caregivers and communities as learning partners, PBS KIDS helps to empower children for success in school and in life.”

- Math Games: <https://pbskids.org/games/math/>

## Methods

### *Keywords and Search Strings*

The following keywords and search strings were used to search the reference databases and other sources:

- (math\* OR “math games”) AND (online OR digital) AND (elementary OR “middle school” OR “middle grades”)

### *Databases and Resources*

We searched ERIC, a free online library of more than 1.6 million citations of education research sponsored by the Institute of Education Sciences (IES), for relevant resources. Additionally, we searched the academic database ProQuest, Google Scholar, and the commercial search engine Google.

### *Reference Search and Selection Criteria*

In reviewing resources, Reference Desk researchers consider—among other things—these four factors:

- Date of the publication: Searches cover information available within the last ten years, except in the case of nationally known seminal resources.
- Reference sources: IES, nationally funded, and certain other vetted sources known for strict attention to research protocols receive highest priority. Applicable resources must be publicly available online and in English.
- Methodology: The following methodological priorities/considerations guide the review and selection of the references: (a) study types—randomized controlled trials, quasi experiments, surveys, descriptive data analyses, literature reviews, policy briefs, etc., generally in this order; (b) target population, samples (representativeness of the target population, sample size, volunteered or randomly selected), study duration, etc.; (c) limitations, generalizability of the findings and conclusions, etc.
- Existing knowledge base: Vetted resources (e.g., peer-reviewed research journals) are the primary focus, but the research base is occasionally slim or nonexistent. In those cases, the best resources available may include, for example, reports, white papers, guides, reviews in non-peer-reviewed journals, newspaper articles, interviews with content specialists, and organization websites.

Resources included in this document were last accessed on June 23, 2020. URLs, descriptions, and content included here were current at that time.

This memorandum is one in a series of quick-turnaround responses to specific questions posed by education stakeholders in the Appalachia region (Kentucky, Tennessee, Virginia, and West Virginia), which is served by the Regional Educational Laboratory Appalachia (REL AP) at SRI International. This Ask A REL response was developed by REL AP under Contract ED-IES-17-C-0004 from the U.S. Department of Education, Institute of Education Sciences, administered by SRI International. The content does not necessarily reflect the views or policies of IES or the U.S. Department of Education, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. government.